

Nature itself in a mirror space-time

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Abstract

The unity of the structure of matter fields with flavor symmetry laws involves that the left-handed neutrino in the field of emission can be converted into a right-handed one and vice versa. These transitions together with classical solutions of the Dirac equation testify in favor of the unidenticality of masses, energies, and momenta of neutrinos of the different components. If we recognize such a difference in masses, energies, and momenta, accepting its ideas about that the left-handed neutrino and the right-handed antineutrino refer to long-lived leptons, and the right-handed neutrino and the left-handed antineutrino are short-lived fermions, we would follow the mathematical logic of the Dirac equation in the presence of the flavor symmetrical mass, energy, and momentum matrices. From their point of view, nature itself separates Minkowski space into left and right spaces concerning a certain middle dynamical line. Thereby, it characterizes any Dirac particle both by left and by right space-time coordinates. It is not excluded therefore that whatever the main purposes each of earlier experiments about sterile neutrinos, namely, about right-handed short-lived neutrinos may serve as the source of facts confirming the existence of a mirror Minkowski space-time.

1. Introduction

A notion about neutrinos introduced by Pauli may be based logically on the availability in nature of an unbroken flavor symmetry [1]. From its point of view, each type ($l = e, \mu, \tau, \dots$) of charged lepton has his own ($\nu_l = \nu_e, \nu_\mu, \nu_\tau, \dots$) neutrino. Such pairs are united in families of a definite [2,3] flavor

$$L_l = \begin{cases} +1 & \text{for } l_L \ l_R \ \nu_{lL} \ \nu_{lR} \\ -1 & \text{for } \bar{l}_R \ \bar{l}_L \ \bar{\nu}_{lR} \ \bar{\nu}_{lL} \\ 0 & \text{for remaining particles} \end{cases} \quad (1)$$

confirming that nature itself testifies [4,5] in favor of a flavor symmetrical connection between the structural particles in difermions

$$(l_L, \bar{l}_R) \ (l_R, \bar{l}_L) \quad (2)$$

$$(\nu_{lL}, \bar{\nu}_{lR}) \ (\nu_{lR}, \bar{\nu}_{lL}) \quad (3)$$

This in turn implies that the left (right)-handed neutrino in the field of emission similarly to a kind of charged lepton [6] can be converted into a right (left)-handed one without change of flavor [7]. Such transitions, however, encounter many problems connected with properties of a chiral invariance and a mirror symmetry of the best known types of Dirac fermions.

They reflect the availability of so far unobserved characteristic feature of a latent structure of mass, energy, and momentum and thereby require in principle to fundamentally change our presentations about matter fields. Without such a change, the unified field theory construction of elementary particles still remains not quite in line with nature.

Therefore, we consider the question as to whether there exists any mass dependence of spin nature and, if so, what the expected connection says about the dynamical origination of spontaneous mirror symmetry violation. Insofar as a chiral invariance problem is concerned, the results following from its consideration call for special presentation.

2. Helicity criterion for the Dirac equation

To express the idea more clearly, it is desirable to use the Dirac equation, which for the four-component wave function $\psi(t, \mathbf{x})$ may be written as

$$i\partial_t\psi = \hat{H}\psi \quad (4)$$

where it has been accepted that

$$\hat{H} = \alpha \cdot \hat{\mathbf{p}} + \beta m \quad (5)$$

Here $\hbar = c = 1$, $E = i\partial_t$, and $\mathbf{p} = -i\partial_{\mathbf{x}}$, the matrices α , β , and γ_5 in the form as were suggested by Dirac [8] have the following structure:

$$\alpha = \begin{pmatrix} 0 & \sigma \\ \sigma & 0 \end{pmatrix} \quad \beta = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix} \quad \gamma_5 = \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix} \quad (6)$$

Among them I is a unity 2×2 matrix, and σ are the Pauli spin matrices.

Such a choice is based historically on the fact [8] that α and β give the possibility to directly pass from (5) to the relationship involving the mass, energy, and momentum

$$E^2 = \mathbf{p}^2 + m^2 \quad (7)$$

Furthermore, if neutrinos are of free particles with an energy $E > 0$ then

$$\psi = u(\mathbf{p}, \sigma) e^{-ip \cdot x} \quad (8)$$

With these conditions, α and β separate the four-component spinor u into two two-component spinors. We must, therefore, replace it with

$$u = u^{(r)} = \begin{bmatrix} \chi^{(r)} \\ u_a^{(r)} \end{bmatrix} \quad (9)$$

where an index a distinguishes $u^{(r)}$ and $u_a^{(r)}$ from one another.

The two-component spinors $\chi^{(r)}$ and $u_a^{(r)}$ reflect just a regularity that (4) constitutes the two most diverse equations

$$E\chi^{(r)} = (\sigma\mathbf{p})u_a^{(r)} + m\chi^{(r)} \quad (10)$$

$$Eu_a^{(r)} = (\sigma\mathbf{p})\chi^{(r)} - mu_a^{(r)} \quad (11)$$

This united system in turn establishes two more highly important connections

$$u_a^{(r)} = \frac{(\sigma\mathbf{p})}{E+m}\chi^{(r)} \quad \chi^{(r)} = \frac{(\sigma\mathbf{p})}{E-m}u_a^{(r)} \quad (12)$$

and thereby describes a situation in which the availability of each of the two classical solutions of the Dirac equation equal to

$$u^{(r)} = \sqrt{E+m} \begin{bmatrix} \chi^{(r)} \\ \frac{(\sigma\mathbf{p})}{E+m}\chi^{(r)} \end{bmatrix} \quad (13)$$

says in favor of an explicit mass dependence of spin nature. It is fully possible therefore that mirror symmetry may be violated at the expense of a mass of a particle [9] itself.

Many authors state that there is no connection between the mass of the neutrino and its spin nature. The existence of the latter would seem to contradict our observation that the upper (lower) sign of a self-value $s = \pm 1$ of the helicity operator $\sigma \mathbf{p} = s|\mathbf{p}|$ corresponds to the right (left)-handed neutrino at the definite choice of spin and momentum directions. But, as stated in (4), this implication follows from the fact that in the form as it was accepted, the compound structure of the Dirac equation depending on the mass, energy, and momentum is not in a state to give a categorical answer to the question of what of the two four-component spinors (13) together with

$$\chi^{(1)} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \quad \chi^{(2)} = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \quad (14)$$

describes the same left ($s = L = -1$) or right ($s = R = +1$) spin state of the fermion.

It is also relevant to include in the discussion the free antiparticle with

$$\psi = \nu(\mathbf{p}, \sigma) e^{-ip \cdot x} \quad (15)$$

If we choose its spinor

$$\nu = \nu^{(r)} = \begin{bmatrix} \nu_a^{(r)} \\ \chi^{(r)} \end{bmatrix} \quad (16)$$

at which an index a is responsible for separation of $\nu^{(r)}$ and $\nu_a^{(r)}$ from one another, for the case $E < 0$ when (4) is reduced to

$$|E| \nu_a^{(r)} = -(\sigma \mathbf{p}) \chi^{(r)} - m \nu_a^{(r)} \quad (17)$$

$$|E| \chi^{(r)} = -(\sigma \mathbf{p}) \nu_a^{(r)} + m \chi^{(r)} \quad (18)$$

one can find that

$$\nu^{(r)} = \sqrt{|E| + m} \begin{bmatrix} \frac{-(\sigma \mathbf{p})}{|E| + m} \chi^{(r)} \\ \chi^{(r)} \end{bmatrix} \quad (19)$$

Comparison of (19) with (13) at $r = 1, 2$ leads us to the choice once more of the sign of a self-value of quantum mechanical operator $\sigma \mathbf{p}$, namely, of the sign of a helicity s , confirming that we cannot establish the spin nature of elementary particles until an equation itself of their unified field theory is able to separate these particles by the mirror symmetry laws.

3. Mass, energy, and momentum matrices

The circumstance in the preceding section seems to indicate that each of transitions

$$\nu_{lL} \leftrightarrow \nu_{lR} \quad \bar{\nu}_{lR} \leftrightarrow \bar{\nu}_{lL} \quad (20)$$

may serve as the group of arguments in favor of the unidenticality of masses, energies, and momenta of neutrinos of the different components without change of their lepton flavors. If we recognize this difference in masses, energies, and momenta, accepting its ideas about that the left-handed neutrino and the right-handed antineutrino refer to long-lived leptons, and the right-handed neutrino and the left-handed antineutrino are of short-lived fermions, we

would follow the mathematical logic of the Dirac equation from the point of view of the flavor symmetrical mass, energy, and momentum matrices

$$m_s = \begin{pmatrix} m_V & 0 \\ 0 & m_V \end{pmatrix} \quad E_s = \begin{pmatrix} E_V & 0 \\ 0 & E_V \end{pmatrix} \quad \mathbf{p}_s = \begin{pmatrix} \mathbf{p}_V & 0 \\ 0 & \mathbf{p}_V \end{pmatrix} \quad (21)$$

$$m_V = \begin{pmatrix} m_L & 0 \\ 0 & m_R \end{pmatrix} \quad E_V = \begin{pmatrix} E_L & 0 \\ 0 & E_R \end{pmatrix} \quad \mathbf{p}_V = \begin{pmatrix} \mathbf{p}_L & 0 \\ 0 & \mathbf{p}_R \end{pmatrix} \quad (22)$$

where V must be considered as an index of a distinction.

At these situations, any of interconversions (20) can be explained by the particles $\nu_{lL}(\bar{\nu}_{lR})$ and $\nu_{lR}(\bar{\nu}_{lL})$ possessing unidentical masses, energies, and momenta. But their Coulomb nature has been created so that to each type of C-even or C-odd charge corresponds a kind of current [5]. There exists, therefore, the possibility that a classification of leptonic currents with respect to C-operation admits the existence of two types of leptons of vector V_l and axial vector A_l currents of different C-invariance [10]. Unlike the fermions of a C-odd charge, the mass of which is strictly an axial vector (A) type, the particles of a C-even charge have mass of a vector (V) nature [5].

It is already clear from the foregoing that (21) and (22) refer to those neutrinos among which there are no elementary objects with axial vector masses, energies and momenta.

In the presence of such matrices, the structure of the unified field theory equation of neutrinos of vector types becomes fully definite and behaves as follows:

$$i \frac{\partial}{\partial t_s} \psi_s = \hat{H}_s \psi_s \quad (23)$$

in which

$$\hat{H}_s = \alpha \cdot \hat{\mathbf{p}}_s + \beta m_s \quad (24)$$

and E_s and \mathbf{p}_s correspond to quantum energy and momentum operators

$$E_s = i \frac{\partial}{\partial t_s} \quad \mathbf{p}_s = -i \frac{\partial}{\partial \mathbf{x}_s} \quad (25)$$

As well as in (21), the index s here expresses, as we see later, the unidenticality of space-time coordinates $[(t_s, \mathbf{x}_s)]$ of the left- and right-handed particles. Then it is possible, for example, to describe the field of the free neutrino in a latent united form

$$\psi_s = u_s(\mathbf{p}_s, \sigma) e^{-ip_s \cdot x_s} \quad E_s > 0 \quad (26)$$

Because of (6), (21), and (22), the four-component wave function $\psi_s(t_s, \mathbf{x}_s)$ is reduced at first to the two two-component wave functions and, next, the latter separates it into four possible parts. Formulating more concretely, one can write the field u_s in a general form

$$u_s = u^{(r)} = \begin{bmatrix} \chi^{(r)} \\ u_a^{(r)} \end{bmatrix} \quad (27)$$

So, we must recognize that (23) together with (6), (21), (26), and (27) constitutes the naturally united system of Dirac equations

$$E_V \chi^{(r)} = (\sigma \mathbf{p}_V) u_a^{(r)} + m_V \chi^{(r)} \quad (28)$$

$$E_V u_a^{(r)} = (\sigma \mathbf{p}_V) \chi^{(r)} - m_V u_a^{(r)} \quad (29)$$

Their two-component spinors correspond to the fact that in them, m_V , E_V , and \mathbf{p}_V are the flavor symmetrical 2×2 matrices, which are absent in a classical system of Dirac equations. Instead they include the usual mass, energy, and momentum.

It is not surprising therefore that at the availability of a connection

$$u_a^{(r)} = \frac{(\sigma \mathbf{p}_V)}{E_V + m_V} \chi^{(r)} \quad \chi^{(r)} = \frac{(\sigma \mathbf{p}_V)}{E_V - m_V} u_a^{(r)} \quad (30)$$

any of the two solutions of the new Dirac equation (23) equal to

$$u^{(r)} = \sqrt{E_V + m_V} \begin{bmatrix} \chi^{(r)} \\ \frac{(\sigma \mathbf{p}_V)}{E_V + m_V} \chi^{(r)} \end{bmatrix} \quad (31)$$

respond to the same left- or right-handed neutrino.

To investigate further, we present (31) in an explicit form

$$u^{(1)} = \sqrt{E_L + m_L} \begin{bmatrix} 1 \\ 0 \\ \frac{(\sigma \mathbf{p}_L)}{E_L + m_L} \\ 0 \end{bmatrix} \quad (32)$$

$$u^{(2)} = \sqrt{E_R + m_R} \begin{bmatrix} 0 \\ 1 \\ 0 \\ \frac{(\sigma \mathbf{p}_R)}{E_R + m_R} \end{bmatrix} \quad (33)$$

It is seen that $u^{(1)}$, $\chi^{(1)}$, and $u_a^{(1)}$ characterize the left-handed neutrino, and $u^{(2)}$, $\chi^{(2)}$, and $u_a^{(2)}$ describe the right-handed neutrino.

For completeness we include in the discussion the free antineutrino with

$$\psi_s = \nu_s(\mathbf{p}_s, \sigma) e^{-ip_s \cdot x_s} \quad E_s < 0 \quad (34)$$

At the same time, (6) and (21) replace the spinor ν_s for

$$\nu_s = \nu^{(r)} = \begin{bmatrix} \nu_a^{(r)} \\ \chi^{(r)} \end{bmatrix} \quad (35)$$

and thereby transform (23) into the two other equations

$$|E_V| \nu_a^{(r)} = -(\sigma \mathbf{p}_V) \chi^{(r)} - m_V \nu_a^{(r)} \quad (36)$$

$$|E_V| \chi^{(r)} = -(\sigma \mathbf{p}_V) \nu_a^{(r)} + m_V \chi^{(r)} \quad (37)$$

By following the same arguments that led to (19), but having in view the equality

$$\nu^{(r)} = \sqrt{|E_V| + m_V} \begin{bmatrix} \frac{-(\sigma \mathbf{p}_V)}{|E_V| + m_V} \chi^{(r)} \\ \chi^{(r)} \end{bmatrix} \quad (38)$$

one can also make a conclusion that

$$\nu^{(1)} = \sqrt{|E_L| + m_L} \begin{bmatrix} \frac{-(\sigma \mathbf{p}_L)}{|E_L| + m_L} \\ 0 \\ 1 \\ 0 \end{bmatrix} \quad (39)$$

$$\nu^{(2)} = \sqrt{|E_R| + m_R} \begin{bmatrix} 0 \\ \frac{-(\sigma \mathbf{p}_R)}{|E_R| + m_R} \\ 0 \\ 1 \end{bmatrix} \quad (40)$$

which show that $\nu^{(1)}$, $\chi^{(1)}$, and $\nu_a^{(1)}$ correspond to the right-handed antineutrino, and $\nu^{(2)}$, $\chi^{(2)}$, and $\nu_a^{(2)}$ respond to the left-handed antineutrino.

Thus, we have established the full spin structure of the Dirac equation in which it is definitely stated that

$$\sigma \mathbf{p}_L = -|\mathbf{p}_L| \quad \sigma \mathbf{p}_R = |\mathbf{p}_R| \quad (41)$$

Simultaneously, as is easy to see, the neutrino ν_{lL} and the antineutrino $\bar{\nu}_{lR}$ are the left-polarized leptons, and the neutrino ν_{lR} and the antineutrino $\bar{\nu}_{lL}$ refer to the right-polarized fermions.

In these circumstances, it seems possible to use ψ_s in the form

$$\psi_s = \begin{pmatrix} \psi \\ \phi \end{pmatrix} \quad \psi = \begin{pmatrix} \psi_L \\ \psi_R \end{pmatrix} \quad \phi = \begin{pmatrix} \phi_L \\ \phi_R \end{pmatrix} \quad (42)$$

Uniting (42) with (23) and solving the finding equations concerning $\psi_{L,R}$ and $\phi_{L,R}$, it can also be verified that

$$E_{L,R}^2 = \mathbf{p}_{L,R}^2 + m_{L,R}^2 \quad (43)$$

The difference in lifetimes of neutrinos of the different components can explain the spontaneous mirror symmetry violation, at which they have unidentical masses, energies, and momenta. This leads us to the conclusion that

$$E_L = i \frac{\partial}{\partial t_L} \quad E_R = i \frac{\partial}{\partial t_R} \quad (44)$$

$$\mathbf{p}_L = -i \frac{\partial}{\partial \mathbf{x}_L} \quad \mathbf{p}_R = -i \frac{\partial}{\partial \mathbf{x}_R} \quad (45)$$

Insofar as the mass is concerned, we start from the special comparison theorem [11] for the Dirac equation that m_s similarly to all E_s and \mathbf{p}_s must be quantum operators such as

$$m_L = -i \frac{\partial}{\partial \tau_L} \quad m_R = -i \frac{\partial}{\partial \tau_R} \quad (46)$$

where τ_L and τ_R are the lifetimes of the left- and right-handed particles, respectively.

Furthermore, if these situations are of fundamental principles of quantum mechanics, our reasoning refers to all the particles interacting according to (23), which unites the massive Dirac fermions of vector types.

Such a connection arises as a consequence of the ideas of corresponding mechanism laws responsible for the dynamical origination of spontaneous mirror symmetry violation. From their point of view, nature itself separates Minkowski space into left and right spaces concerning a certain middle dynamical line. Thereby, it characterizes any Dirac particle both by left $[(t_L, \mathbf{x}_L)]$ and by right $[(t_R, \mathbf{x}_R)]$ space-time coordinates. In this it is additionally assumed that τ_L and τ_R correspond in (46) to the lifetimes of a particle in the left and right Minkowski spaces, respectively. It is not excluded therefore that whatever the main purposes the recent experiments [12] about sterile neutrinos, namely, about right-handed short-lived neutrinos may serve as the first confirmation of the existence of a mirror Minkowski space-time.

4. Conclusion

There exists of course a range of old phenomena in which appears a part of the dynamical origination of spontaneous mirror symmetry violation. A beautiful example is the solar neutrino problem [13].

At first sight, an active left-handed neutrino passing through the medium from the Sun to a detector on the Earth can be converted into a sterile right-handed neutrino [14] not interacting with the field of emission, for example, in the reactions $\nu_{eL,R} + Cl^{37} \rightarrow e_{L,R} + Ar^{37}$ as well as in other phenomena with neutrinos. Therefore, it seems that an observed flux of neutrinos will be half that of the starting one. However, as we shall see, this is not quite so. The point is that the left-handed long-lived neutrino at the interaction with matter will be converted into a right-handed short-lived neutrino without change of its lepton flavor. The right-handed neutrino in turn interacts with the field of emission until it will not virtually decay forming the real left-handed neutrino of the same flavor. Under such circumstances, a flux of solar neutrinos does not suffer a decrease in quantity.

In the standard electroweak model [15-17], it has been usually assumed that in nature the right-handed neutrino is absent. This is of course intimately connected with the prediction of a two-component theory [18] of the neutrino, expressing the idea of parity nonconservation in the weak interactions [19]. According to one of its aspects, the matrix γ_5 in the chiral presentation of the Weyl [20] constitutes the projection operator $(1 - \gamma_5)/2$ allowing one to choose only the left components of the four-component spinor.

Such a procedure, however, redoubles the results of theoretical calculations in all flavor symmetrical processes with weak charged currents even in the presence of a normalized multiplier. Insofar as the weak neutral currents are concerned, the terms with γ_5 appear in them as the axial vector components of these currents. The number of solar neutrinos and the structural phenomena originating in the detectors on the Earth coincide, as follows from considerations of flavor symmetry. This conformity requires comparison with experiment of any of the two equal parts of a theoretical estimate of a flux of solar neutrinos.

Thus, if the structure of the standard model is not quite in line with ideas of a new Dirac equation, (23), it needs in special reconstruction.

Finally, insofar as the Dirac Lagrangian and its structural components are concerned, all of them together with some aspects of spontaneous mirror symmetry violation (not noted here) will be presented in the separate work.

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